FURTHER STEPS
IN THE
PRINCIPLES
OF
AGRICULTURE

HENRY TANNER F.C.S

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FURTHER STEPS

IN THE

PRINCIPLES OF AGRICULTURE

BY

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EXAMINER IN THE PRINCIPLES OF AGRICULTURE UNDER THE GOVERNMENT DEPARTMENT OF SCIENCE

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PREFACE.

THE Author has endeavoured in this elementary book to carry forward the studies commenced in the Alphabet of the Principles of Agriculture, so that the pupil may be prepared for entering upon the use of a more advanced work. Familiar illustrations and simple language have been made use of as far as possible, in the endeavour to secure the attention of those to whom scientific details have — as a rule—very little attraction.

October 1881.

INTRODUCTION.

A YOUTHFUL lecturer is supposed, in the following pages, to be instructing his younger brother, so as to assist him in preparing for the higher instruction given in our Science Classes. Any assistance which enables a person to have a clear and definite idea of the elementary truths necessary for understanding Lectures on the Principles of Agriculture, is likely to render the work which is subsequently accomplished, much more thorough and complete.

The practice of learning portions of text-books, so as to give a parrot-like power of repeating them, with an accuracy which is only equalled by the profound ignorance of the truths expressed, generally arises from the fact, that the pupils do so because they have no clear and definite knowledge of the elementary truths on which their instruction is based —such truths being so very simple that many will not condescend to teach them.

This will not be sanctioned in our Elementary Schools, and we may confidently anticipate that the pupils sent from these schools will approach our Science Classes with minds so thoroughly prepared

for the instruction to be given, that there will be no need for them to undergo the process of "cram," because they will have been well prepared for making a good and satisfactory progress in the study of the Principles of Agriculture.

FURTHER STEPS

IN THE

PRINCIPLES OF AGRICULTURE.

LESSON No. XIII.

The lessons which we may learn from the Alphabet of the Principles of Agriculture are very simple, and easily remembered. We have now to go further on, and learn something more; but these lessons will be just as simple and easy as the others, if you remember what has already been taught to you. We have talked about plant-food, and about plants making use of it, and growing larger by means of that food, but we must now learn something more about this plant-food.

You know that your own food consists of many different bodies, and of these you also know that potatoes, bread, beef, mutton, cheese, butter, milk, and similar substances are used as food. Thus, when you speak of your food, you include in that term a number of different kinds of food, and it is desirable for us to feed upon several different sorts of

food. It is very much the same in the case of **plant-food**, for this also consists of **several different kinds of food**, and we must now try to learn something about them. If you were to be placed amongst a number of new schoolboys, you would at first find it difficult to learn and to remember their names, but you would soon make friends, first with one, and then with another, until at last you would know many of them. For our present purposes, you have only to learn the names and the history of some few bodies, and when you know these, we shall be able to talk about them more freely, and you will advance in your knowledge of plant-food. To understand all that is desirable will take many years of careful study, but you will find that there is much to be learnt which will be very easy and very useful.

The first sort of food we have to notice is called **potash**, and to many it will appear to be a curious word, but you will remember it very easily if you divide that word into two, thus **pot-ash.** You have seen an iron pot used for boiling water or something else in. We took one out with us at the time of the school treat last summer, for we wanted to boil water in it for making tea in the park at Holt Castle. You remember that we took some charcoal, the boys gathered some sticks, and we soon made a fire around the iron pot. When the tea had been drank, and the feast had come to an end, you might have seen something under the pot, and if any one had asked what it was, you might have

said "ashes." This came from the wood we had burnt, and you might possibly have called it wood-ashes, because the ashes came from the wood. It is very likely you would not have been content simply to call it ashes, because there are other ashes, such as coal-ashes, and a sharp lad would have said in reply to the inquiry, "Wood-ashes are under the pot."

But, fifty years ago, before railways had helped us to send coal into all parts of the kingdom, wood was very generally used for burning in our fires. On almost all our farms wood was grown for this purpose, and wood-ashes were then as common as coal-ashes are now. They were seldom called wood-ashes, because there were rarely any other ashes seen; but they were often called **pot-ashes** from being the ashes found under the iron **pots** then used for cooking purposes. The term pot-ashes is even now applied to some of these ashes which are sent to us from America, where they burn large quantities of vegetable matter to make these ashes for our use. For some years past it has been found necessary, for trade purposes, to dissolve out of these ashes the most soluble portion. When such clean solution is dried by evaporation, we obtain what is now known as potash. This **potash** is one sort of food which plants require for their healthy growth.

Questions.

Does your food consist of one or of several bodies?

Do plants require several different sorts of food?

Can you give the name of one kind of food used by plants?

What do you mean by potash, and why was it so called?

Did you ever help to make some?

What was found under the iron pot, when they boiled the water in Holt Castle park?

Are there any other kinds of ashes?

Why are wood ashes now so seldom made in this country?

Where do they now make pot-ashes in large quantities?

How are these pot-ashes made?

In washing the ash is all of it dissolved?

How is the soluble part again brought into a dry and solid state?

What is that soluble portion called when it is dry?

Remember

Plant-food consists of several different kinds of food. If we know the names and characters of these, we shall be better able to understand the growth of plants. Potash is one of the substances used as food; it is obtained from the ashes of vegetable matter. The very soluble portion of those ashes is separated by water, and afterwards dried.

LESSON No. XIV.

In our previous lesson we were noticing the manner in which wood and other vegetable matter left ashes upon the ground after they had been burnt, and we also noticed the means whereby a portion of the ash was made use of in the form of potash. When a fire is burning, and vegetable matter is being changed into ashes, we often see smoke passing away from the burning heap. Thus, by the aid of a fire, we are dividing that vegetable matter into two distinct parts.

First, **the ash,** which, as you know, remains behind.

Second, **the smoke,** which passes into the air. The smoke chiefly consists of water, in the form of steam or vapour, and mixed with it there are various gases. Some of these gases are without colour, and we cannot see them any more than you can see the air we breathe, or the gas we burn for the purpose of giving us light. Of these gases, there is one with which you must become well acquainted, for it can be a friend in promoting the growth of our crops; but it can also become an enemy, and destroy life. It is known by the name of **carbonic acid**, and we may hope that you will soon become acquainted with it as a new friend.

In order that you may the more easily understand about it, we will divide the name into two parts as we did before, and you will see that it then becomes **carbon**-ic **acid**, or an **acid made from**

carbon. Now, what is carbon? We may say that charcoal and coal consist so very largely of carbon, that for present purposes you may consider a piece of wood or bone charcoal, or a piece of coal, as being a piece of carbon. If then you set a piece of wood charcoal on fire, it will burn away very steadily, and it will leave nothing behind but a small quantity of ash. The carbon has thus gone out of sight, and it has taken the form of a gas. It is not lost, but it has changed its form, and we call it in that new form **carbon**-ic **acid**. Thus we burn vegetable matter which contains much **carbon**, and we make much of it into **carbon**-ic **acid**.

But if we carefully guided that carbonic acid into a chamber, or green-house, in which plants were growing under the influence of bright sunshine, it would be quite possible for the plants to breathe in some of that carbonic acid and use it as **a food**. Thus, whilst by fire we made the carbon into carbonic acid, by the help of the growing plant and the sunshine we could also have some of that gas turned into carbon again. The fire turns much of the vegetable matter into smoke, the growing plant brings back much of it into the form of vegetable matter again. Thus the fire does not destroy what is burnt, but it rather prepares it for being used again.

You will wish to know how this can be done, but in order that you may do so we must tell you of another body, which becomes a companion of the *carbon, and helps it* in the work. So long as the

carbon is without this companion, you will observe little change in its appearance; but when the carbon burns, it becomes united with a gas called **oxygen,** and in this way the carbonic acid is made. Thus, during the burning which you see, these two bodies become partners, and away they go into the air with the smoke. After a time, when passing under the leaves of some tree or plant, they are drawn into the leaf, very much the same as you might suck air into your mouth, and then the carbonic acid is used as food. If the sun is shining brightly, the leaf soon makes use of that food, and in doing so it keeps the carbon, but it sends out the oxygen to do the same work again. Thus, like as the parent bird flies from its nest during the day time to bring back food for its young ones, so does this oxygen travel away to find a new partner, which it may make useful as food for that, or some other, growing plant. You will notice that very little of this work is seen by us, but it goes on quietly and steadily all through the day. If we allow the food to be brought to the leaves, then the plant can make growth, but if we crowd the plants together (Lesson 10) so that they have no proper supplies of fresh air, then they cannot breathe in their food, and their growth is checked.

Questions.

When we burn vegetable matter, what passes away into the air?

What remains behind after the fire has ceased?

Into how many parts does the fire divide that vegetable matter?

Can you say what the smoke has in it?

Is there one gas in it, which we have to remember?

What is carbon?

If we burn it, what is formed?

Can carbonic acid be used by plants as food?

What companion helps the carbon to be so useful?

How do plants make use of the carbonic acid?

Do they feed on it by day, and by night?

What becomes of the companion which made the carbon so useful as food?

Is there any advantage gained by giving plants plenty of free air?

Remember

By burning wood and other vegetable matter, the carbon they contain is formed into carbonic acid, and plants feed upon this carbonic acid by separating the carbon it contains. Thus, whilst the fire burns the carbon into the form of a gas, which we cannot see, it is again brought into use by the growing plant taking it as food, and adding it to itself.

LESSON No. XV.

Did you ever see any one burning a sulphur match? It is not pleasant to use these matches, but many years ago it was thought to be a very good way for getting a light. A flint and a piece of steel were used to give a spark, which, falling upon some burnt linen, made it begin to burn slowly. Some small pieces of wood, with a little sulphur upon them, were used as matches, and these quickly caught fire from the slow burning linen, and gave the bright flame we wanted. This **sulphur** is another substance which plants use as food, and the oxygen which helped the carbon into a form on which plants could feed upon it, does the same good work for the sulphur also.

We will now see how this is done. When the sulphur match burns there is a smoke made, just as there was when the carbon was burning, but the sulphur smoke is more clearly seen, and it makes you cough if you breathe it. In this burning of the sulphur, it also takes in a companion—oxygen—which did good service before, and thus the hard and solid sulphur is turned into a gas. By means which are used in chemical works, some more oxygen is joined to it, and the gas is then dissolved in water, and we then have it as **sulphur**-ic **acid.** This means an **acid made from sulphur.**

You will have noticed that our old friend oxygen came in to help us again, and if we had not had its help, the sulphur would have remained very much

as we found it on the matches. But there is a great difference in the way in which plants use this sulphuric acid, as compared with the carbonic acid. You will remember it was said, that the carbonic acid was breathed into the leaf, and the oxygen was separated in the leaf. The carbon was kept, and the oxygen was sent away to do more work. Not so with the sulphuric acid, for it would destroy any part of the plant. If a piece of straw were to be dipped into sulphuric acid, the straw soon becomes quite black. Thus it is that although plants want the sulphur as food, another change has to take place which shall make it act more gently. It would never do to make use of a food, which, instead of helping the plant to grow, was so strong that it destroyed it. As you progress you will learn how nicely this power is turned to a good purpose, and is not allowed to injure the plant which feeds upon the sulphur. For the present we must leave you with these facts to remember about the sulphur, and the means whereby it becomes formed into sulphuric acid. You must also bear in mind that this strong acid, can be made perfectly gentle and safe for plants to feed upon, but this will be better explained in our next lesson.

Questions.

What was used on matches to make them burn more freely?

How were those matches used?

Is sulphur wanted by plants as food?

What is it that helps to make the sulphur useful as food?

What is it that joins the sulphur when it burns?

Does the sulphur then remain hard and solid?

What acid is made from sulphur?

Why is it so called?

Can this acid be used by plants as food?

Can plants use any acid body as food?

Can you name one acid which is so used?

Can plants feed upon sulphur when it is hard and solid?

How do we get the sulphur in a liquid form?

What do we then call it?

What happens if you place a piece of straw in sulphuric acid?

Can pure sulphuric acid be used as plant-food with safety?

Remember

Sulphur is another body used by plants as a part of their food. We see it sometimes on matches, but plants cannot feed on it until it has been turned into a liquid form. The sulphur is formed into sulphuric acid, which is a very strong acid, and would injure the plant if it were to be so used. It is not useful as plant-food, until it has been made very gentle in its action.

LESSON No. XVI.

We were talking about matches in our last lesson—some of the sulphur matches that were commonly used many years ago. Since that time matches have been used which do not need the old flint and steel to give the spark. You know the matches which are made with phosphorus, and most boys have seen some of this on their fingers, making them—when in the dark—look as if they were on fire. This **phosphorus** is also used by plants as food as well as the sulphur. Now, it is curious to think that matches should have any connection with plant-food, but you see that the phosphorus which is used for making matches now, as well as the sulphur which was wanted for the old sort of match, are both useful in plant-food. You have, therefore, one more sort of plant-food to remember—**phosphorus**.

Plants cannot use it in a pure state, for it would burn them; but our old friend oxygen comes in to help us again, and it does so by becoming a partner with the phosphorus, and then it makes **phosphor**ic **acid**, or the **acid made from phosphorus.** You will easily remember this, for any boy who knows anything about phosphorus matches, will not forget that plants want some of the same substance for their food.

But plants, although they want phosphorus for food, can only use it as food when it is quite **gentle** *in its action,* and **safe** for its work. Pure phosphorus,

as we have said, is not safe, neither is it gentle enough, even when it has been made into phosphoric acid. Another group has therefore to be made, and to do this another companion has to be added to the phosphoric acid. There are several bodies, any one of which could be so used, but of these we have as yet only mentioned one, and we will therefore use this one to explain the change which takes place. If some potash be added to the phosphoric acid, in a proper manner, we have a new body formed, and we call it phosphate of potash. This is perfectly gentle, and quite suitable as food. By taking up some of this phosphate as food, the plant gets a supply of two kinds of food at once, for it gets the phosphorus and the potash. If you look at the name of the body **phosph**-ate of **potash** you see quite enough to remind you of the two kinds of food it contains —**phosphorus** and **potash.**

In your previous lesson we did not explain how the strong sulphuric acid could be made gentle, but that is treated in exactly the same way. Some other body—potash, for instance—is properly added to the sulphuric acid, and then we get a new body, which we call **sulph**-ate of **potash.** The sight of this name reminds you of the **sulphur** and the **potash** that it contains. You can easily see, that here also are two kinds of food ready for the use of plants—sulphur and potash—and they are ready in a form which is perfectly safe for the plant to feed upon.

Although we have now taken up four of the

different kinds of food necessary for plants, we have not gone far from the fire we had at the school treat in Holt Castle Park. We found the

Carbon in the charcoal and wood used for our fire;

Sulphur
Phosphorus } in the matches;

Potash in the ashes we left on the ground.

These four bodies you will certainly remember, and if you do not forget our good helper—**oxygen**—you will then probably be able to explain the changes these bodies undergo in preparing themselves for the work they have to do. A little further care will enable you to know all the different foods used by plants, as easily as you learnt the names of your own school-fellows.

Questions.

What was put upon the matches, used with the old flint and steel?

What sort of matches have since been used?

What have these two kinds of matches to do with the food of plants?

Have you ever seen any phosphorus?

Can phosphorus be used as a food in its pure state?

Why must it not be given as food?

What does the oxygen do when it comes near to the phosphorus?

What new body is then formed?

Why is it so called?

Can the phosphoric acid be used as food?

How do we make phosphoric acid more gentle in its action?

If potash be added to phosphoric acid, what is then made?

What two kinds of food for plants do we find in the phosphate of potash?

If we added potash to sulphuric acid, what should we make?

What two kinds of food for plants are in the sulphate of potash?

Can you repeat the names of the four kinds of plant-food you have already learnt, and show what they had to do with a certain fire?

Remember

Phosphorus, which has been so commonly used for making matches, is another body used as a food for plants. It is too strong to be used in its pure state, and when made into phosphoric acid it is still not quite gentle enough. Potash may be added to it, and then we have phosphate of potash made, which is fit for use, and contains both phosphorus and potash. Both of these bodies are wanted as food for plants.

LESSON No. XVII.

As a matter of course, you know the **salt** which we use with our food, and you have no doubt often tasted it. Now, salt is made up of two kinds of plant-food, and it is necessary that you should know what these are. It is quite possible to divide them; and, although they are companions now, we can take one away, and then the other has no choice but to fly away. The names of these two bodies are **soda**,[1] which you will easily remember, and **chlorine**, which is the most troublesome name we have had. You would like to know, how it is we can part these two companions. We do it by sending a stronger one to take one of them away, and then of course the other is left alone. You remember we were talking about sulphuric acid, and this is a very strong acid. If we put some of this upon some salt, it takes the soda away from the chlorine. We cannot see it do this, for it remains in the liquid; and as the chlorine is then left all alone, it passes away by itself. You can see the chlorine passing away, and if you happen to breathe some of it, you will then remember it as a very disagreeable companion, even if you cannot remember its name.

Soda—having carbonic acid combined with it—is known in every kitchen; almost every one knows it

[1] For obvious reasons, preference has been given to this *term rather than* to that of sodium.

by name, and most persons know it by sight. It is just one of those useful kitchen supplies, that helps to soften water both for cooking, and for washing purposes. If it is rightly used it improves the food which is cooked, and it lessens the labour of washing; hence it is valuable for household purposes. You will not be able to forget the name of **soda** very easily. Whenever you see salt placed upon the table, it will help to remind you of the fact that it is made up of two bodies. Plants want both of these bodies as food, and their names are chlorine and soda.

As salt is found in very large quantities in this country in mines, it is chiefly from this source that we obtain our supplies of soda and chlorine. It is a most valuable mineral product, and although it can be bought very cheaply, yet we want it so much for making the different forms of soda and chlorine we use, that we should be sadly at a loss without it. Where salt is scarce they make it from sea water, which is run into shallow ponds, and then dried by the sun. But, wherever the salt may be got from, it still contains these two kinds of plant-food—the chlorine and the soda.

We have shown you how to separate these two bodies, but plants could not use the chlorine when it has been so parted from the soda. It is probable that most of the chlorine plants make use of, is obtained by taking some salt as food. They get the soda they want, not only by using salt, but also by the help of several other soda compounds.

Questions.

For what purpose do we make use of salt?

Can you say what substances it contains?

How may these be separated?

Why do we use sulphuric acid for this purpose?

What happens when we pour some sulphuric acid upon salt?

What becomes of the soda?

What becomes of the chlorine?

Is it pleasant to breathe chlorine?

Is soda frequently used in our kitchens?

Did you ever see any soda?

What is soda useful for in the kitchen?

Where do we get our salt from?

Where do they get salt from in countries where there are no salt mines?

What does salt always contain?

How do plants get the chlorine they need?

How do they get the soda they want?

Remember

In the salt, we so generally use at our tables, we have two other kinds of food required by plants—chlorine and soda. The former of these is a gas which causes great pain if we breathe it. Plants cannot use it in this state, for it would injure them; but they feed upon it by taking salt. Soda is commonly known by its use in our kitchens, and it is a very *useful food for plants.*

LESSON No. XVIII.

A WHITE clay is often used in the workshops in which they make china cups and saucers, and other things of that sort. You have most likely seen some of it, and you know it is very much like the clay we find in our fields. The white clay contains two bodies, which are necessary for plant-growth, and you will easily remember their names. One of these is called **silica**, and you will be a very silly lad if you forget it. This is required as a food for plants, especially for those having white straw, such as our wheat, barley, and oats. There is another body found with it which is called **alumina**, but this is not used as a food by any of our cultivated crops, still it is very useful in helping their growth. It is very likely that you have never heard of Alumina before, but you cannot forget the name of Alum, which is made from it, if you have once had some given you instead of barley sugar. You would be well laughed at, if you began eating some of it, thinking it was sweet, and it proved to be very far from pleasant. It is quite clear you would not be caught a second time, and what is more, when you have tasted it, you will not forget **alum**. As you remember **alum**, you cannot forget **alum**ina, especially as you will not wish to taste alum again.

These two bodies, **silica** and **alumina**, we find in white clay, and because they are partners, we join their names, and call the firm **silica**te of **alumina**.

If, therefore, any one speaks of silicate of alumina, it is this union of silica and alumina which is meant, and in the white clay we have it in a tolerably pure state. You do not want any one to tell you that all clay is not white. In the brickfield, where they are making bricks for building, the clay is not white, but it has a colour something between a red and a brown. That is a capital clay for bricks, but the difference between it and the white clay is, that the one has something in it to colour it, whilst the other has not. This clay is really coloured by **iron**, and if you think for a minute, you must remember seeing iron of the same colour. The iron-rust on the garden roller is just between a red and a brown, and if you could well rub some of that iron-rust into some of the white clay, you would make it very much like the clay in the brickfield. This iron is another body which is used as food for plants. You do not need a word to be said, to help you to know what body we mean when we speak of iron. It may be as well to say, that the clean bright iron becomes rusty, and takes this red-brown colour, because two bodies we have often spoken of have been working busily at it. These two bodies are our friends oxygen and carbonic acid, and these prepare the bright iron for being useful for plants. They are always busy if they have the chance, and when you know more of them, you will see that they are very active and true friends of the farmer. We cannot say that they are doing us any good service *in rusting the* garden roller, and so it is that neither

these or any other friendly helpers are perfect, but if we give them a full chance for doing what we want done, we shall see that their good services are very far greater than any loss they may cause us.

Questions.

What is white clay used for?

What plant-food does it contain?

Can you remember the names of any other body found in this white clay?

Is this useful for plant growth?

What is made from alumina?

What name do we give silica and alumina when they are united?

Where do we find the silicate of alumina in a tolerably pure state?

Is all clay of this white colour?

What was the colour of the clay in the brick-field?

What gave the clay that colour?

How could we make white clay something like it?

Is iron used by plants as food?

Is the iron used when it is bright and hard, or when it has become soft by rust?

What friendly helpers prepare the iron for being used as food?

Do they do any injury to any of the things we use in our gardens, and on our farms?

Do they do more good than injury?

Remember

In a pure clay, which is white, we find silica, which is useful as a food for plants, and alumina, which is also useful, but is not used as food by any cultivated crops. In the ordinary clay of the brick-yard, the colour is often given by the rust of iron, which is another plant-food.

LESSON No. XIX.

As we were walking over the farm some short time since, we saw them putting **lime** upon the ground. You have seen masons using lime for making mortar, but when you see it being so used another time you must remember that it is used by plants as food. It was partly for this reason that it was put upon the farm, for plants like it, and they want a proper supply in the soil. The lime does much more good in the land, than even giving it a supply of food; but we are now chiefly noticing this use, and we shall speak of its other work at another time.

But some of our limestone has another body mixed with it, called **magnesia**. You have heard of magnesia before, for it is one of those white medicines which come from the druggist's shop. You could not tell the difference between magnesia and flour, if you simply looked at both of them.

It is very likely you are getting very tired of so *many new* names, and you may begin to think that

plants want a very great many things for food. We have now nearly come to the end of the list, and of this you will be very glad, for it is about the hardest part of the work to remember so many different names. There is one more name, and it has been kept to the last, because it is very useful when people are tired and weary. You have no doubt seen persons so very tired that they faint, and then some one gets a smelling-bottle for them, with some ammonia in it. If you have ever smelt it, you will know that it is very strong, and if you are not careful in smelling it, you will not forget it in a hurry. Try, then, to remember **ammonia**, as another food which plants make use of, and we shall then be able to talk of something more pleasant.

You must not think that plants want too many kinds of food. It does seem a very long list to think of; but we all want quite as many kinds of food as even plants do. We must not complain of plants wanting so many things, if we do the same. However, we have now got over the great difficulty, and even if you cannot at once name the full list, you will certainly know something of them when we speak of them as doing their proper work.

Questions.

Have you ever seen lime?
What is it used for by masons?
What is it used for by farmers?
What is it used for by plants?

Is there any other body sometimes found with it?

Do plants want it for any purpose?

What does magnesia look like?

Can you give me the name of any other body used by plants as food?

Is this ammonia ever used by ourselves?

Did you ever try to smell it?

Why do persons use it in this way?

Do you think plants want too many kinds of food?

Do you want quite as many?

Remember

Lime, magnesia, and ammonia, are all required by our crops as food, and are very useful for helping them to grow. They are not only useful as food, but they have other work to do in the soil, which will be noticed as we progress.

LESSON No. XX.

It may be as well to look over the work we have done, and make up a list of the different bodies which are useful for plant-growth. These are as follows:—

Silica.	*Alumina.*
Phosphoric Acid.	Lime.
Carbonic Acid.	Ammonia.
Sulphuric Acid.	Potash.
Chlorine.	Soda.
	Magnesia.
	Iron.

You can look upon these as so many old friends, and you can remember something about each. They are now placed in two lines, because this shows the order in which they choose their partners. If, for instance, silica wanted a partner it would not choose the phosphoric acid, or the carbonic acid, or any in that line, but it would choose one from the other line. At the top of the other line stands alumina, an old friend of silica, and a capital partner. It is just the same with all the others, but we will take another example. If lime, for instance, wanted a partner, it would not choose one in its own line, but would pick one from the other line. It is almost like so many gentlemen and ladies choosing their partners for some of our games. The gentlemen choose their partners from amongst the ladies, and not from amongst the gentlemen. There is, in this way, a proper arrangement of partners, and they are always chosen from the opposite line.

You should also understand that there is much preference shown in the choice of partners, for they are not only taken from the opposite list, but there is a distinct order of choice. Thus two partners may be very quietly settled, but if another is brought in, it may lead to a change. We have a well-known example when the carbonate of soda is mixed with sulphuric acid. The carbonate of soda was quietly settled; if we dissolve it in water all remains quiet, but if we add some sulphuric acid we find a violent change takes place. Speaking freely, we may say that the soda likes the sulphuric acid better than

the carbonic acid, and as the sulphuric acid is the stronger acid of the two, the carbonic acid is turned out, but a great disturbance is made in this being done. So it was in the case of the salt to which some sulphuric acid had been added (Lesson XVII.), there the chlorine was turned out. In some cases these changes take place quietly, and nothing happens which even looks like a conflict. Chemistry teaches us much as to these very numerous changes, but we cannot do more here than explain to you that such changes of partners do take place, sometimes quietly, and sometimes with some disturbance.

Questions.

How many bodies useful for plant-growth can you remember?

Why did we divide them into two lines?

Are these bodies ever separated after becoming partners?

What general rule is followed in their choosing their partners?

What conditions lead to such changes?

Can you explain the change which takes place, when sulphuric acid is added to carbonate of soda?

What happened when sulphuric acid was added to salt?

Is there ever any violent action in making these changes?

Do these changes ever take place quite gently?

Are these changes numerous?

What science helps us to understand these changes?

Remember

The various substances required by plants as food may be made into two groups, according to the manner in which they select partners for helping them in their duties. We speak of these unions as combinations. They take place in regular and definite order, and after a distinct choice has been made. The study of chemistry teaches these facts very fully, and such knowledge is very valuable.

LESSON No. XXI.

HAVING cleared our course by explaining to you what substances are used as food, and having made a very brief reference to the grouping of some of these bodies as partners, we can now speak of matters which will be more pleasant to young students. In the *Alphabet of the Principles of Agriculture* (Lesson II.) you learnt that the first food a young plant had to live upon came from the seed. You also learnt (Lesson I.) that plants can only take their food by two means. It must either enter the plant dissolved in water, or it must be taken into the plant as a gas, very much as we breathe in the air. We will now take a grain of wheat as an example, to explain the manner in which the young plant obtains its first food.

If we cut a grain of wheat open, we see that it is dry and almost like flour. It does not look as if it could give much soft juicy food to the young plant. But one of the conditions necessary for enabling the grain of wheat to grow is that it must be wetted by water. So long as the seed had to be kept in store, so long it was necessary for it to be dry, and to be kept from water. We now want it to produce a young plant, and we must not now keep it dry, but rather give it water. As soon as the water has soaked into the seed, other conditions being favourable, instead of it being able to dissolve something, we find that in the seed there is little or nothing ready to be dissolved. Some change has to be made, and there is a new body formed in the seed as soon as it begins to grow. The work which this body (diastase) has to do, is to make the floury matter of the seed into sugar or gum, or something like it, so that it may be dissolved in the water. Thus, directly the plant begins to make growth, there is a supply of a sweet milky fluid prepared in the seed, ready for feeding the young plant.

The seed of wheat consists of two parts:—

(*a*) **The germ**, or the true seed.

(*b*) **The food** which is to feed that germ.

The germ is generally a very small part of any seed, and this is so in the seed of wheat. As soon, then, as this germ commences to make growth, the supply of liquid food must be given, and the young germ soon builds up into itself the food given, and *it becomes longer*, gradually forming a small but

perfect plant. You will see that growth was impossible without food, and that food had to be given to the young germ dissolved in water. The food stored up for the young plant was very dry, because it had to be kept, and it would not dissolve in water, but a special body is formed in the seed, which helps us to give the food in a proper condition.

This work we know as "**Germ**ination," by which we commonly mean a growth of the **germ,** and the formation of a strong young plant. For proper growth we want a steady supply of water, not simply enough to wet the seed, and help the seed to begin its growth, but we want the supply of water to continue, so that growth, when it has begun, may not be stopped (*Alphabet*, page 14), but may steadily continue, so that a strong healthy plant may be produced.

Questions.

Whence does the young plant get its first supply of food?

In what two forms can plants receive food?

Which form is necessary for the young plant?

Does the food exist in the seed in a soluble condition?

What do we mean by a soluble condition?

Why must we have our seeds dry and floury?

How does the food become soluble?

When does the change first commence?

What body is required to change the food?

What is formed from the food which is useful for the growth of the young plant?

What are the two portions of a seed?

What do we mean by germination?

What is necessary to help the germ to commence growing?

Is water wanted after the growth has commenced?

What will happen if the supply of water is not properly kept up?

What does happen when the germination is properly carried on?

Remember

The germination of the seed cannot commence without a supply of water to moisten the seed thoroughly well, but the store of food is not soluble in water, therefore, as soon as germination begins, we have some diastase formed, and its duty is to make the food soluble in water, so that the young plant may be able to use it. We must keep up a proper supply of water to the seed; if this is not done, the young plant becomes sickly, and often dies.

LESSON No. XXII.

BUT water alone will not make a seed grow. Two *other* conditions are necessary, and of these a supply *of air is one.* *If* you could keep a seed without air

coming to it, however much you might wet it, there would still be no growth. If a little air were given to it, then you might have some growth, but it is always unsafe only to do things "by halves." If it be done, let it be well done, and not simply half done. It is very much the same with seeds, for if they have only a little air coming to them, they may begin to grow, and then die for want of a further supply. In such a case the plant dies, and the seed has done no useful work.

You will like to know how it is we give seeds a supply of air, and how it is that we can give a larger or a smaller supply of air. We are now speaking of seeds making their growth in the soil, and you will see that if we place those seeds in clay soil, when it is soft and muddy, they will be closely covered up by the clay. The result of this would be, that the clay would shut out the air, and prevent it coming to the seed. When you know that air is really wanted by the seed for helping it to grow, you will see how very necessary it is that we should not do anything to prevent the air getting to the seed.

When land is properly prepared for the growth of seed, care is taken that it shall be loose and open, so that the air can enter into it. If you had a heap made up of large stones, you know that the wind could pass into that heap, because there are open spaces between the balls. If you wanted to stop the wind going into the heap, you might do so by mixing up some clay with water, and placing some

of that mud outside the heap. You know very well that you could in this way stop the wind from going into the heap. Very much the same thing happens, on a small scale, when a seed is sown in a soil in which it is covered all round with clay. It cannot get the air it wants, and it cannot grow. A good farmer does all in his power to prevent his seed being lost in this way. He makes the soil loose and open, so that the air can get into it, and help the seed he sows to make a healthy growth.

The fact is, that very few know the full value of a good supply of air for helping plants in their growth. It is of great value for the seed in its early period of growth, and it continues to be most useful to the plant up to the time when its growth is finished. A good farmer knows, that if he does not give fresh air to the plants he grows they cannot prosper. From the time of sowing the seed, to the time when the crop is ready for use, a supply of fresh air is wanted, and the best farmers take care that their crops shall not be without a proper supply of fresh air from first to last.

Questions.

What is necessary for the growth of a seed, in addition to a supply of moisture?

What happens when a little air is given, but not enough for healthy growth?

If a seed be covered up closely in a clay soil, *does it grow?*

What do we do to the soil to make the growth of the seed safe?

Why does the wind enter a heap of large stones?

Can we prevent the wind going into it?

What often stops the air going into the soil?

At what times in the growth of a crop is a supply of air wanted?

How do we secure a supply of air during the growth of the seed?

Do you remember any other supplies of fresh air which our crops require?

What happens to the seed if fresh air be not given?

What happens to the growing crop, if the plants are so crowded that they cannot breathe freely?

Remember

A proper supply of air is necessary for the growth of the seed. We secure this supply by making the soil loose and open. The free supply of fresh air is wanted by plants all through their lives, from the time the seed begins to grow, up to the time when the growth of the crop is completed.

LESSON No. XXIII.

As a supply of fresh air is so very useful for plants, we will now explain why it is so. The air is chiefly made up of two gases, and our friend oxygen is

one of them. You will remember that oxygen is useful in preparing food for plants, for this has been already spoken of in some of our Lessons (XIV., XV., XVI., and XVIII.) There are several other ways in which it is also useful. Of these we may say that the seed requires oxygen during its germination, and it wants a supply of air as a means for getting this oxygen. If a bottle full of oxygen were placed before you, there would be nothing seen in looking at it, to show that it was not common air. To make use of a common remark, it is very likely you would say that the bottle was empty, even when it was quite full of this gas—oxygen. Think of it, then, as air having very strong powers for work.

We cannot make a fire burn without air; but the air is useful because of our friend oxygen being in it, and thus there are several duties which the air performs, which are really done by the oxygen. But whilst our friend oxygen is very useful, it is generally very much too fast about its work, and something has to be done to make it work more slowly. The air has been so formed that it does its work fast enough, but not too fast. We find a second gas in the air, which puts a check upon the **oxygen,** and prevents it working too fast, and this gas is called **nitrogen.** You may have seen cases in which a young horse is being driven in a carriage, and they often put an old and very steady horse by his side. The steady horse keeps the young horse from going too fast, and the nitrogen does just the same for the oxygen.

The nitrogen does not look in any way different from common air, but it is very little that it will do in this form, and it is rather noted for doing very little. This makes it very suitable for lessening the activity of the oxygen. It is just another instance of the slow horse keeping the fast horse from going too quickly.

Although the air chiefly consists of these two gases, there are other bodies existing in it in small quantities, and these have each their proper work to do. For the present it will be enough for you to know, that oxygen is necessary for the growth of the seed, and a supply of air is chiefly necessary —in this instance—for the sake of the oxygen it contains.

Questions.

Of what does the air chiefly consist?

Can you give the name of one of the gases found in the air?

Do you remember any work which oxygen does in preparing plant-food?

Do seeds want oxygen when they germinate?

Where do they get it from?

If a bottle full of oxygen were before you, what would it look like?

Does oxygen generally do its work quickly or slowly?

Can we make a fire burn without oxygen?

Where does the oxygen generally come from?

How is it made to work more slowly?

What is nitrogen noted for as a gas?

What does it look like?

Are there any other bodies in the air besides the oxygen and nitrogen?

What portion of the air is required by seeds, when they germinate?

Remember

The air we breathe consists chiefly of oxygen and nitrogen mixed together. The chief reason for air being wanted by seeds which are germinating, is for giving them a supply of oxygen; but as it works so very quickly when it is alone, it is mixed with nitrogen, which makes it work more slowly, and more safely.

LESSON No. XXIV.

You cannot make much progress in the Principles of Agriculture without something being said about **analysis.** It will therefore be desirable for you to know what is meant by analysis, and for you to be able to know what it teaches us. We shall not take a difficult analysis to begin with, and, it may be, you can make a simple analysis yourself, which will show you what is meant by it. We weigh the different bodies found by analysis, and put the weights in such order that they show how much of *each sort is* present. The analysis you will find

most easy, is one which any one may possibly have seen done upon a farm. We went over to a farm not long since, and we saw a heap of corn which had just been threshed out. It was a very bad sample of corn, for the field had not been kept clean, and the weeds had grown freely. It was a mixed crop of beans and peas, and there was some wheat growing in it, with a great many weeds. When the corn was examined to see what was in it, by passing some of it over a fine sieve we took out the seeds of some weeds, and these weighed two pounds. Then we passed it over another sieve, and we got out some wheat, which weighed thirteen pounds. After this we found we had some peas weighing forty pounds, and the rest of the corn was beans, and these weighed forty-five pounds. Now, you can easily give the analysis of that mixed corn, and it would be as follows:—

Beans	45	pounds.
Peas	40	"
Wheat	13	"
Weeds	2	"
	100	"

Thus it is with all analyses, by right and proper methods the chemist separates the different things that are present, and then they are weighed. They are then written out in proper form, and any one who understands the subject, can see at once how much of each sort is present. You can see how it was with the corn, and you will soon know what

is meant by a proper analysis. Chemists must become very skilful before they can make analyses correctly, and it is of course very different work to the sifting of the corn already mentioned. If we leave out of the question how it is done, you will understand that proper analysis shows, how much of each sort is present in the body which is worked upon.

We will now take a real analysis done by a chemist, and this shows the composition of what would be left on the ground if two tons of clover hay had been burnt. You know that the wood and charcoal we burnt in the park at the time of the school treat, left some ash on the ground. If we had burnt two tons of clover hay, we should have made a very large quantity of ash, and this analysis shows what it would have contained. You will be able to understand every word of it, now you have advanced so far in your studies.

Analysis of the Ash of two tons of Clover Hay[1]:—

Potash	52	pounds.
Soda	7	"
Magnesia	35	"
Lime	111	"
Phosphoric Acid . . .	20	"
Sulphuric Acid . . .	13	"
Silica	10	"
Iron	3	"
Common Salt . . .	8	"
	259	"

[1] *First Principles of Agriculture*, page 24.

Questions.

How do we make an analysis?

Can you say how some corn was once analysed?

By whom are analyses of food and manures done?

Is it easy or difficult to make one of these analyses?

Can you explain what is meant by the analysis given of the ash of clover hay?

What do you mean by the ash of clover hay?

How would you separate the ash from the clover hay?

What was done to the clover hay in getting the ash out of it?

How much clover hay would have to be burnt to give so much ash?

How much ash did it produce?

How much potash did it contain?

How much lime?

How much soda? etc. etc. etc.

Remember

Analysis is carried out by chemists, who adopt proper methods for separating different bodies, and, after weighing them, they make a plain statement of the results. If any one knows the bodies which have been weighed, there should be no difficulty in knowing what the analysis is intended to explain—namely, the weights of the bodies present in the substance which has been analysed.

LESSON No. XXV.

ONE of the first uses we shall make of your knowing something about analysis, is to explain what sort of food the young plant obtains from the seed. By means of analysis we are able to learn, what different bodies are found in a grain of wheat. You know that, for a time, the only food the young plant receives is sent to it from the seed. The question naturally arises, does the seed contain all the different kinds of food, which we have said are necessary for plant-growth? It was a long list of different bodies (p. 30), and you may naturally say, Is it possible that all of these can be found in one grain of wheat?

The following shows the analysis of the ash of the grain of wheat:—

Potash	29·96
Soda	3·88
Magnesia	12·28
Lime	3·40
Phosphoric Acid	45·88
Sulphuric Acid	·32
Silica	3·36
Iron (Per-oxide)	·80
Common Salt	·12
	100·00

You may not be so far on with your arithmetic, as to understand the relative value of these figures, but you will be able to look down the list of names and *say whether all* the bodies needed for food are there

or not. There are two bodies absent, carbonic acid and ammonia, but all the rest are there ready for feeding the young plant. Those foods which are absent are supplied from the seed, although they are not shown in this analysis of the ash of wheat.

When we burnt the wood in the Park for boiling the water, we divided the wood into two parts (page 11), the ash which remained behind, and the smoke which passed into the air. So also, if we burn the grains of wheat we get the ash, and the smoke. All those bodies we have named exist in the ash, for it is an analysis of the ash, but the bodies present in the smoke are not shown in that analysis. You know that we stated (in Lesson XIV.) that carbonic acid was one of the gases which were to be found in the smoke. Hence there was something in the wood, and also in the wheat, which could be made into carbonic acid. It is just the same with the ammonia also, for both of these bodies can be supplied, in such a convenient form, so that the young plant has a full supply provided for its use. The first source of food, you know, is the seed, and by analysis we learn that the wants of the plant are very perfectly supplied, even at this early period in its life.

Questions.

What do you mean by analysis?
What does it teach us as to the seed of wheat?
Whence does the germ obtain its first food?

Does that food contain many different bodies?

Can you give the names of any of them?

What two bodies are not shown in the analysis of the ash of wheat?

What do we mean by the ash of wheat?

What became of the other part of the wheat?

When carbon is burnt, what is produced from it?

Does the seed contain a very perfect supply of food?

How do you know this?

Remember

The supply of food contained in the seed is very perfect, and thus the first growth of the germ is provided for. By an analysis of the grain of wheat, we learn that all the food which is really wanted has been stored up in the seed.

LESSON No. XXVI.

THE food which the young plant receives from the seed, has been shown to be very perfect in the case of wheat. Well-grown seeds of other plants are equally ready to give a full supply of food. The plant having commenced life with such good supplies of food, has after a time to seek from the soil and the air that which it needs. Here it is that its *difficulties* generally begin. We do not find in our *soils any equally* perfect supplies of food, because, as

soils differ in character and composition, so must these supplies of food differ also. You know that only a small portion of the soil is present in the form of plant-food. We may therefore look upon the soil as a hunting ground, through which the roots of the crop strike out in search of food. If soils were one mass of perfect food, the roots would have less work to do than at present, but plants have to gather their food from amongst much matter which is not plant-food.

You remember that plant-food consists only of those portions of the soil which are in an "active" condition, which really means being in a state ready for use by the growing plant (*Alphabet*, page 23). Another difficulty arises from that plant food being imperfect, in some one or more particulars. All plants do not take the same quantities of the several substances they need for food. For instance, although all crops require phosphoric acid, some want it in large quantities, whilst others only want a small supply. If we keep on growing crops which take large quantities of phosphoric acid, we find those crops getting smaller and smaller, and this is very likely to arise from a short supply of this one food. But the land might be able to produce a large crop of some other sort, which did not need so much phosphoric acid. This is how it very often happens that a soil can grow one crop when it is unable to grow another. Just as a builder may have the materials proper and necessary for putting up one kind of house, when he could not build one of another

sort. He can only make use of such materials as he has ready for use, and the crop is in the same position. This influence upon the crop is not limited simply to the phosphoric acid, as in the instance given; it applies to each and all of the different substances used as food for plants. Our crops want a perfect supply of food, and if their wants are not supplied, they do not grow with vigour, but they look sickly and weak. They thus show the farmer that they are in want of something or other; but it is too often the case that, whilst he sees they are in want, he does not know what is required. You have often seen little children looking very ill, and you have heard some one say, "That child wants something to make it well;" and so it is with plants. A doctor may be called in, and he may give the child that which will make it well. We may hope that some day we shall be able to find out exactly what any and every crop may be wanting, and by giving it the needed supply, make it more healthy and more productive.

Questions.

From whence do plants draw their first supplies of food?

Which is the second source of food?

Do we find soils having an equally perfect supply of food, as the seed?

Does the soil consist entirely of plant-food?

Why has the soil been compared to a hunting-ground?

Do all crops take the same quantity of each kind of food?

Suppose one kind of food is made use of very largely, what happens?

Does one sort of food ever become largely used up, whilst others are still remaining in the soil?

How does this influence the crops which can be grown?

How may a builder's store be compared to a partially fertile soil?

When plants want food which the soil does not contain, do they give any sign of such want?

Remember

The soil is the second source of plant-food, but, unlike the seed, it has often a very imperfect supply of such food. In such cases the growing crop cannot progress well, but it looks sickly and ill. Even then, the soil may be able to grow some other crop, in abundance, and in good health.

LESSON No. XXVII.

THE difficulties which farmers have had to fight against in keeping their crops healthy and productive, have led to two or three different plans being adopted to lessen some of their losses. The first of these plans has been giving the land more **rest.** Some may be disposed to say, the land does

not take active exercise, therefore it cannot need rest. But whether it be the case of a lad exhausted by active exercise, or that of the field which has had its active matter greatly reduced, both need to remain quiet for a time, to regain fresh power for new work. Let us see what change takes place in the soil, during the time it is thus preparing by rest, for doing stronger and better work.

This change very largely consists in an increase in the plant-food in the soil. We have in all soils, of good quality, a complete supply of all the different kinds of food needed by our crops; one portion being in an "active" condition, and a very much larger portion being in a "dormant" state. The difference between these two conditions has been already explained (*Alphabet*, page 21), and it is very important for you to remember them. If, by growing large crops, we use up so much of the active matter that the produce becomes smaller and smaller, we are obliged to increase the quantity of that active matter before we can grow larger crops. One means for doing this is to turn some of the dormant matter of the soil into an active condition. We call it dormant because it is in a sleeping condition, and hence the farmer has to "awaken" some of it, and make it go to work.

In doing this, he has two or three friends to help him, and you know two of them very well, for the oxygen and carbonic acid work away for him just *as fast* as he will let them. It is to give these *gases the best* chance of going to work, that he

ploughs the land up as rough as possible. When the soil lies quite flat and level, there is less surface open to these gases, but when it is laid up as roughly as possible, they have a better chance of doing their work. After a time the farmer may plough it again, and this brings a fresh surface open to the air, and these two gases then work away at it. The result of their work is, that much of the dormant matter becomes active, and able to do good work in feeding any crops which may be sown afterwards.

Besides these gases we have help given by the frost, for this breaks up the soil, and gives more surface for these gases to act upon. Thus, although we call it a time of **rest,** it is only a stoppage from the growth of crops, for there is a constant series of changes going on, whereby much of the matter in the soil is aroused from sleep, and made into active plant-food. In this way we can make the land more fertile, and better able to grow good crops. Rest to the land, may be compared to rest from school-work. Boys who work hard at their lessons need rest, and their holidays prepare them for going to work again, after a time of rest, with new power and fresh energy. Thus, from the earliest period in the world's history, it has been found necessary to give the land rest; to stop it for a time from producing crops. You now know that one great cause of such rest being useful to the land, is that some of the dormant matter is made active. We speak of this dormant matter as "locked away" in the

soil, but by good tillage we arouse some of it from sleep, and make it useful.

Questions.

Why are soils allowed to have rest?

Do boys require rest after doing hard work?

What work do soils do to make them need rest?

What change takes place in soils, whilst they are taking rest?

Do you remember the difference between the active and the dormant portions of the soil?

What friends help the farmer whilst the land is taking rest?

How does a farmer increase the surface which is exposed to the air?

How does the frost help to improve the land?

If a proper rest is given to the soil, can it do more work afterwards?

Is it an old custom to give land rest?

What do you understand by food being "locked away" in the soil?

Remember

Soils which are worked hard, so that they produce large crops, do sometimes need rest, and they do better work after they have had a proper rest. It is a very old law, which is often neglected, and our crops are injured by not giving the land proper rest, *for we thereby* increase its supply of plant-food.

LESSON No. XXVIII.

Another plan by which farmers try to prevent their land growing bad crops, is by **changing the kind of crop** which is grown. A builder might have a very large store of everything he wants for building houses. He may have a large supply of stones, plenty of bricks and wood, and he may have doors and windows of different sizes. If he kept on building houses always of one kind, a time would come when he would have a short supply of some things he required for the work. If, for instance, he had been building some houses with stone walls, after he had been almost stopped for want of stone, he may have built a house which took very little stone and a great many bricks. A farmer is often in a very similar position, **for different crops**, like our various kinds of houses, **require different materials.** If a farmer were to keep on growing the same crop, he might find his crops become small and not very healthy, and then he would probably grow some other crop. As a rule, farmers do not wait for such losses arising, but they try to prevent the trouble taking place, by growing first one kind of crop, and then another sort. Thus, you see, a good farmer, who knows he cannot continue to grow one kind of crop, has a regular succession of crops which will suit his soil and his climate. In such a case he is very much like a wise and prudent builder, who builds different sorts of houses and sheds, according to the supplies

he has ready for his use. In this way, the farmer tries to prevent any failure in his crops by having a change in his crops.

If a builder found that some of his stores were getting short, it is very likely that he would order some more to be sent for his use. A farmer also, if he finds his supply of some kinds of plant-food becoming short, he also would order a further supply, and he would do so by buying some manure. The use of manure, is therefore the third means for preventing our crops failing for want of a proper supply of food. By this means any food which is wanted, can be got ready for the crop.

But what should we say of a builder, who, if he were wanting some timber for his work, bought a lot of stone or brick instead? We should all see that he was not spending his money wisely, if his purchases would not help him. Many farmers are spending money, year after year, in buying manures, and yet they buy much that is not wanted. Too often they fail to buy what is wanted, and after all their trouble and expense they cannot grow large crops, because something is wanted which is not provided. Some of these days farmers will know just what they ought to buy better than they now do, and then they will save much money which is now lost, by simply buying the proper supply of that which is necessary for the growth of large crops of good food. You remember that in another lesson (*Alphabet*, page 45), we told you that "if a farmer *buys a dear* manure, which the land does not want,

and if he neglects to buy a cheap manure that is necessary, he then makes another large loss of money."

Questions.

What is gained by having a change in the crops grown on the land?

If a farmer keeps on growing any one crop, does he keep on drawing the same kind of food from the soil?

What is the result of his doing so?

Can a farmer grow a large crop of one sort, when he cannot grow a large crop of another kind?

What is the cause of this?

How do farmers try to keep up a proper supply of plant-food in the soil?

Does it matter what manure a farmer buys, so long as it is a manure?

Do farmers ever waste money, by buying manures which do not suit their soils?

What rule should guide a farmer in buying manures?

Is an expensive manure, always a suitable and useful manure?

Remember

To prevent our soils becoming unable to grow good crops, farmers generally avoid growing the same crop year after year, and they have a change of crops. They also use manures to supply any absent food which the crops require, but care must

then be taken to buy just what is wanted, and not buy something which is not wanted.

LESSON No. XXIX.

THERE are many different kinds of manures used upon the land. Some are made upon the farm, and some are bought and carried to the farm. You know that anything which is grown upon the land, takes much of its food from the soil. If we return to the soil any part of any crop, we repay a part of the loan which was made. If, for instance, we grow a crop of wheat and send part of it to market, keeping the straw until it becomes rotted, if we put that rotted straw upon the land, we repay a part of the loan. The field is enriched by our doing so, because some portion of that which we borrowed is again mixed with the soil. Any and every portion of a crop which is thus returned, makes the land richer and better. It is for this reason that good farmers take care to give back to the land all the manure made upon their farms.

When any part is sent away, as, for instance, the wheat or the oats which is sold to the miller, and which he makes into flour and meal, this part a farmer cannot return to the land. To prevent loss, he buys some manure to take its place. You will learn as you proceed, that farmers spend much money in keeping their land in good condition, *and that it* is very necessary to buy manures for

the soil. These manures are known as "artificial manures," and they are so called because they are manures made by "art" or trade, and by specially skilled makers. The persons who are engaged in this business endeavour to prepare manures which shall make good any losses from which the soil suffers. You know that some of the produce of the land is sent away from the farm; some plant-food is therefore sent away in it, and something has to be returned to the soil instead of it.

There is a very great difference in these artificial manures, for some are good and others are bad; some are dear and others are cheap; some are wanted upon one farm, whilst others are wanted upon other farms. Then there are some artificial manures which supply good plant-food to the soil, and others only act as so many "whips." It is as if, instead of feeding a horse well, the cruel driver gave the horse more whip instead. Thus the farmer often pays for manure, which, instead of giving the land proper plant-food, simply "whips" it into doing more work, and leaves it quite exhausted afterwards.

Questions.

What do we add to the land to make it yield better crops?

Do we improve the land if we add any part of a crop to the soil?

Can you give an instance of this being done?

Why does this improve a soil?

Do good farmers add vegetable matter to the land as manure?

Does the farm lose any plant-food by corn being sent to market?

How is this loss made good?

What are artificial manures?

Why are they so called?

Are all artificial manures good?

Are they all useful to a farmer?

Can money be wasted in buying artificial manure?

How does this loss arise?

Can money be profitably spent in buying artificial manures?

What causes the difference between having this loss, or securing a profit?

Can you explain why some manures give plant-food to the soil and others only whip it into work?

Which treatment do you think is best?

Remember

We add manures to the soil, to repay the loans we receive from the soil in growing large crops. Any portion of the crop, which may be returned to the soil, is a return of a part of the loan. Some of the crop is sent away to market, and the loss is often made good by sending back artificial manure instead. There are very great differences in the value of these manures.

LESSON No. XXX.

There is no manure which is purchased and brought to our farms, which has been as largely used as **lime.** We spoke of it as being **a food** which plants required for their healthy growth, and it was then stated, that there were other duties which it performed, which were quite as important to the crop as the supply of lime for food. You know that potash is obtained by burning vegetable matter, and this is quite the easiest way of getting it. There are large quantities of potash in some of our rocks, but it is rather difficult to separate this as a supply for our use. Hence we let plants do the work for us, and when they have collected the potash we burn them, and take what they have been gathering for many years previously. It is almost the same as we used to do with our bees. They collected honey which we could not gather from flowers, and when they had made a store of it, we used to destroy the bees by fire, and take their store of honey for our own use. We are not so imprudent now as to destroy the bees that work for us, but you will see that in other respects the two cases are very much alike.

Plants, then, collect from the soil a large quantity of potash, but by doing so the soil is robbed of it, so that after a time the land has not enough left in it to meet the demands made by the plants. The result is, that if the plants are to be properly fed,

some **more potash must be made ready** for their use. Lime is used for doing this work. It does not contain any potash, and therefore it does not add any to the land, but it makes some of the dormant matter of the soil active. In this way potash, which could only be slowly separated by the roots of plants, is quickly set free, and the crop can make use of it with very little loss of time.

For this, amongst other reasons, lime is very useful to the farmer, for it is just as good as **plant-food after it has done this work,** as it was at the first.

Questions.

Has lime been largely used as a manure?

Is it useful as a plant-food?

What work does it do in producing plant-food?

How does it help in giving a supply of potash?

What means do we use to get our supplies of potash?

Can plants continue for a long time taking the potash they require?

What happens when the plants cannot get all the potash they want?

What results from adding lime to the soil?

Does lime contain any potash?

How is it that by adding lime, we have in the soil more potash made ready for use?

Is potash ever found in the dormant matter of the soil?

What is the difference between the dormant and the active matters in the soil?

Can the lime be used as plant-food, after it has done this good work of providing potash?

Remember

Lime is not only useful as a plant-food, but it often does some good work in the soil before it is used as food. Soils often have potash in the dormant state, whilst the crops are not able to grow properly for want of some in an active condition. Lime helps to make it active, and therefore useful for the crop.

LESSON No. XXXI.

When vegetable matter is burnt, much of the carbon in it is turned into carbonic acid. When this vegetable matter is buried in the soil, it can, under favourable circumstances, be formed into **carbonic acid**, but it always takes a very much longer time to do it in the soil than when it is burnt. You have seen wood and charcoal burnt in a fire, so that in a short time you have only some ash remaining, and the rest of it is gone off as smoke. We never have **decay** or rotting going on as fast as fire, but after a long time, it is possible for the same change to take place in the soil. On land which is well farmed there is a large quantity of vegetable matter formed in the soil. This **vegetable matter** often

gives the soil a dark colour; and, in general, it is very little more than the roots of plants which once lived, but are now dead.

We call this **organic matter**, because it has been organised, and because it once formed a part of a living plant. If an examination be made of a plant we find that it is built up of very beautiful parts, each portion of which has a regular structure. If you examine a very fine building, you will find that it is made up of many different parts, and each part helps to make the work more perfect. In a plant these parts are wonderfully small, and much more perfect in form than anything we can make. The plant, then, may be looked upon as a very perfect structure, and every portion of it has some duty to perform. Each part is fitted for its own duty, or as we more generally say, it is organised so that it can do its proper work. You may therefore look upon plants as made up of a number of very small organisms, and after these are dead we call them **organ**-ic matter, because it is the matter of which these **organ**-isms were formed.

You will find organic matter often spoken of, but if you remember the reason why that matter is so called, you will have little or no trouble in knowing what is meant by the term. It is the organic matter which disappears in the form of smoke when we burn any vegetable matter. So also the decaying vegetable matter found in our soils, is *some of the* organic matter we have been speaking of.

Questions.

When vegetable matter is burnt, what is the carbon formed into?

Can such a change take place in the soil?

Is there any difference in the time taken in making the change?

On what lands is this vegetable matter largely formed in the soil?

Can you tell by looking at a soil when there is much vegetable matter in it?

What name do we give to this vegetable matter?

Why is it called organic matter?

What do you mean by an organism?

In what respect is a plant like a beautiful building?

Which is the more beautiful and delicate in all its parts?

What becomes of the organic matter when wood is burnt in a fire?

Remember

By the burning of vegetable matter, and also by its decay, we can produce carbonic acid, but the change is quickly made by the aid of fire, whilst it takes place slowly in the soil. The portion of the plant which undergoes this change is known as the organic matter. It is so called because it has been organised, and once formed a part of a living plant.

LESSON No. XXXII.

Now that you know what is meant by the organic matter of a plant, you will be able to learn what the other part of the soil is called. You know that when the organic matter is burnt, it goes off as smoke, and it leaves behind it some **ash**, which you also know is **not organic matter**, and for this reason it is called **inorganic matter.** Thus vegetable matter is made up of two parts. The one part is organic matter, and the other is not organic matter. One portion burns and passes away as smoke and vapour; the other does not do so. These two parts of vegetable matter are very different from each other, and you must remember that they are known as organic matter and inorganic matter.

This inorganic matter, or ash, is very useful to a plant during its lifetime, for it gives it strength and firmness, and helps to keep it up against the wind. When the inorganic matter is not present in sufficient quantity, the plant is weak and feeble. You may have seen corn growing in the field, and the stems being so very weak that much of it could not stand upright, as soon as it had to support any corn at the head. If the plant has plenty of inorganic matter, and you see the wind blowing over it, even when it carries a full ear it stands up strong and firm. We do not find in plants a bony skeleton, *such as animals* have, but for all that, **plants are**

made strong by the inorganic matter they contain.

One of the great objects which a good farmer seeks to secure is a strong plant, able to make a complete and healthy growth. If the inorganic matter is not properly supplied, the plant cannot become strong, and the crop must suffer. This causes a loss to the farmer, and good farmers take care to avoid such losses, for they know that a good crop can only be produced from strong and healthy plants. When there is **a short supply** of any portion of the plant-food, a farmer very quickly sees that such is the case by the general appearance of the crop. To his experienced eye **the plant looks sickly and weak,** and after a short time any one can see yellowish leaves taking the places of those which should have been of a strong and rich green colour. To the farmer this becomes a sort of "**danger signal**," for it tells him that the crop is injured for want of a full supply of food, and he then takes care to add proper plant-food to the soil, or to give the land some rest, before he tries to grow the same crop again. Thus our crops not only want a full supply of inorganic matter, but they must have all the different kinds which they need. The food required for our crops must not only be abundant, it must also be complete.

Questions.

Can you describe which is the organic matter in plants?

What do we call that portion which is not organic matter?

What are the differences between the organic and the inorganic portions?

What good service does the inorganic matter render to the plant?

Have plants a skeleton like animals?

What happens when plants have too little inorganic matter?

How do our crops look which have had plenty of inorganic matter?

Is the produce we obtain from a crop increased by the plants being strong and healthy?

Will a large supply of any inorganic matter keep plants strong and healthy?

If plants must have so many kinds of food, how does the farmer know that all are supplied in the soil?

What does the farmer do when his crops show the "danger signal"?

What is the lesson we ought to learn when we see our crops looking weak and sickly, from want of proper food?

Remember

The ash of a plant is also known as its inorganic matter. It gives strength to the plant, and enables it to give a large produce. If our crops do not find a full supply, and of the right sort, they do not *thrive*, but by their sickly colour they show that they *are in want* of proper food.

LESSON No. XXXIII.

Plants get all their **inorganic matter from the soil**, and in a good soil it is present as plant-food. We have noticed the fact (Lesson XXXII.), that plants become sickly when they do not get all the different kinds of food they want. Some persons think that plants ought to use the food which is in the soil, and if the supply is not exactly what is wanted, they ought to make use of something else. There are many reasons why plants are so made that they show us when they are in want of some particular food; but one reason is enough for the present. This **sickly appearance** is the only means by which we know that we are **growing an imperfect plant.**

In Lesson XXV. it was shown that the seed of wheat contained all the plant-food which was needed for the growth of the young germ. A long list of bodies was given, showing how perfectly the food was provided, but if plants could make healthy growth when the food was **not perfect**, they could not possibly give us seeds which had **a perfect supply** of food for the young plant. It is a very good thing that our crops do show us when we do not give them proper food, for we then try to supply the want. If we grew seed which looked healthy and strong, without its being fit for its proper work, we should have far greater trouble.

The laws which govern vegetable life very generally prevent this trouble arising, by making it very hard and difficult to grow crops which are too weak and too feeble for their proper duties.

It is true that our crops are very particular about their food, and compel us to **make the supply of food perfect**, or else grow some crop for which there is a proper food in the soil. It is a wise law, and one which we must obey. Just as we know more fully what we have in any soil, and also what our crops require, so we shall be able to make them suitable to each other. We have much to learn before we can succeed in doing this, but as we are learning more every day we may hope to succeed before long.

By the use of manures we endeavour to add to the land those bodies which are not present in a proper quantity. There is one way of meeting the difficulty, and that is by adding to the soil that which is needed.

But we cannot say what should be supplied to the soil, unless by careful analysis we have previously learnt what it is that is really wanted.

Questions.

Whence do plants obtain their supplies of inorganic matter?

When plants do not get all they want, how do they show us that they are in want?

If plants cannot get what they want, do they use something else and still look healthy and well?

Does the seed of wheat contain many kinds of food?

Would it be a good seed if any of these foods were absent?

What is necessary to secure a perfect supply of food in the seed?

How are we able to get over this difficulty?

Is this a good law which causes farmers so much trouble?

If plants were not so particular about their food would farming be less difficult?

What help does a proper analysis of the soil give us when the food supply is not perfect?

Remember

It is from the soil that plants get their inorganic matter, and if they do not get what they need they become weak and sickly. This is very desirable, because it is better to supply to the soil that which is really wanted, than it would be to grow imperfect seeds. By a proper analysis of a soil we can learn what plant-food is needed by the soil, and this may be supplied by the use of well-selected manures.

LESSON No. XXXIV.

Active tillage of the soil does, very generally, so far enrich the land, that it becomes more capable of yielding a complete **supply of food** to our crops. It is often observed that land which appears to be

very poor, and which gives very small crops under ordinary cultivation, becomes very productive when some industrious workman digs it, and makes it into a garden. Many such instances are to be met with in all parts of the kingdom. The great cause of this difference is the mode of working the soil, for it gives better crops after a more perfect tillage. Instead of the land being half moved by the plough, it is thoroughly worked by the spade. The difference is not to be traced simply to the fact that one work is done by a plough and the other by the spade, but rather to the fact that the soil is more thoroughly broken up in the one case than in the other. This has already been spoken of (*Alphabet*, page 24), but it is here necessary to explain one of the chief causes of the success which results from the better tillage of the soil.

By thoroughly well working the soil, and by breaking it up into small pieces, **we let the air get into the land.** In the air we have two gases, which we have before spoken of (page 52) as friends to the farmer. These gases are the oxygen and carbonic acid in the air. As soon as these are let into the soil they begin working away at it, and make some of the dormant matter useful for plants to live upon. In other words, they make it active, and therefore useful as plant-food. When this work has gone on for a time, the farmer may plough the land over again, and then fresh earth is open to the air. These gases set to work again and make more *plant-food*, and thus it is that every ploughing and

every movement of the soil helps to make more plant-food. Thus it was that John Busyman, who was always digging, or hoeing, or stirring the soil in his garden (*Alphabet*, page 24), was making plant-food for his crops. So also the steam-plough on the Abbotts Farm, did so much work at one time that there was plenty of soil exposed through the winter for the gases in the air to be busy upon all through the cold and rough weather of that time of the year.

The work was also helped by the rain and the frost of winter, for these kept on moving the surface and bringing fresh earth to the front. If you never noticed how much change is made in the surface of a single lump of earth during a winter, you can scarcely know how much work is done in this way. Let a large piece of clay be placed on a flat stone, or on a wall, before winter, and you will find the first frost will make it quite hard like stone. After a time it will thaw, and you will see it covered with a nice open earth. Another frost will go deeper into the lump, and the next thaw will very likely make the rest of the lump of clay so fine and so open that the gases can pass in and do their work. It is in this way that **frost helps the gases in the air, to make plant-food** in the soil.

Questions.

Does an active tillage of the soil increase its plant-food?

Do our soils generally become more fruitful by good tillage?

What tools do we use for moving the soil?

Does the plough always do bad work?

What is the change we want to make in our soils by the use of the plough or the spade?

What do we gain by breaking the soil into small pieces?

What are the gases in the air which help the farmer?

What do they do in the soil?

How is it that a fresh ploughing makes these gases busy again?

Does every moving of the soil open up more work for these gases to do?

How do the frost and the cold weather help to make more plant-food.

Remember

We can increase the plant-food in our lands by working them so thoroughly that the oxygen and the carbonic acid in the air can get into the soils. When these gases can pass in, they go to work very busily, and they increase the plant-food in the soil. This makes the land more fertile, because many idle, dormant bodies, are brought into active work.

LESSON No. XXXV.

WHEN the air cannot get into the soil it always *makes the land* unable to grow good crops, and we

call such land poor and barren. This may not arise from any want of the food necessary for the crop, but because the plant wants something more than food. We have already said that plants want air to breathe, as well as food to help them to grow. If we give plants plenty of proper food in the land, and if we prevent the air from reaching the roots of the crop, the growth is not good. We see this when a soil is full of stagnant water, for the air is gradually worked out of the ground. By stagnant water, you know we mean water which does not move about in the land. If a bucket were to be filled with large stones, the air could still pass in between them, but if water were to be poured in so as to fill up the openings between the stones, we should turn out the air. Every day that water stopped in the bucket, it would allow less and less air to get to the stones, because of the water being stagnant. The same thing happens in a soil, for the stagnant water keeps out the air which the plants want, and the result is that the crop cannot grow.

Plants want water, so that they may have food passed into them in a form in which they can make use of it. A moderate supply of water is therefore good and useful, but when there is too much of it it ceases to be so, because it is in its wrong place. It has been compared to a dog in a manger, preventing the horse taking his food, and yet unable to make any good use of it. The water really prevents the plant using the food, and the crop is starved for

want of food, because there is too much water to allow of air being properly passed into the soil. This often happens, even when there is plenty of food to give a large and good crop.

This is set right upon our farms by making a drain from the land. If we made a hole in the bottom of the bucket we were speaking of, the water would run out, and air would enter again between the stones. This is just what we do when we make a drain from a field; it lets the water run away, and as the water passes out of the soil so will the air follow, and plants can then make use of their food.

We all take water in some form or other, and it is necessary for us to do so; but if we were to be kept in a pool of water, we should soon find that it was possible to have too much even of a good thing. On many lands this is just the way in which plants are punished, for the water is often allowed to stand around them for many weeks together. There are other injuries from which our soils suffer, when stagnant water remains in the land, but this will probably be sufficient to show the importance of a proper supply of air in the land.

Questions.

If air be kept out of the soil, does this affect the crops?

Can soils be poor and barren, when they have *plenty of good* plant-food in them?

Does the water ever prevent the air getting into the soil?

What is the condition of the water when it does most injury?

Do plants want a supply of water?

Why do not the plants prosper when they have plenty of what they want?

Why is stagnant water in the soil like a dog in a manger?

How do we correct this injury on our farms?

What do you mean by draining the land?

What becomes of the water in the soil?

When the water goes out of the soil, what takes its place?

Can we have too much, even of a thing that we need?

Remember

The fertile character of a soil is often very much decreased by water being stagnant in it. There may be plenty of food present, but plants cannot make a proper use of it when the land is full of stagnant water, for the air is thus kept out of the soil. By means of drains the water can be passed away from the land, and then the air follows the water, and takes its place.

LESSON No. XXXVI.

In addition to the other advantages arising from air passing through a soil, there is one more which

has to be spoken of. In a previous lesson (page 41) it was stated, that although the air chiefly consists of oxygen and nitrogen, there are other bodies existing in it in small quantities, and these have each their proper work to do. Ammonia is one of these bodies, and you know we spoke of it (page 29) as one of the foods which plants require. It is present in the air in very small proportions; but **as the air passes through good soils, it is robbed of all the ammonia it contains.** In this way large quantities are stored up in the soil, and become very valuable for helping in the growth of our crops.

Just as we make our soils free and open in their nature, and especially as we draw air through them by good drainage, so do we enable the land to catch the ammonia which is passing along with it. We make the soil to do the same work **as a net in a river,** for as the water passes through the nets, any fish which are in that water are caught in the net. It is very much the same with the soil catching the ammonia, for the more air there is which passes through the soil, the greater is the chance of catching more ammonia.

But you may like to know how it is the ammonia gets into the air. It would be too much for us to speak of all the means whereby this is done, but one way may be mentioned. You have passed through farm-yards when they are turning over manure, and you may have seen that the men find it like a strong smelling-bottle. This is caused

by ammonia passing away into the air. Many farmers waste much ammonia by its escaping from their manure, and when it gets into the air it does their neighbours as much good as themselves. Do you not remember how the Abbotts Farm gained ammonia, which Mr. Watkins lost by his bad management?[1] Thus, the good farmer enriches his land by some of that which bad farmers waste.

Good tillage of the soil, free exposure of the ground to the air, and a thorough drainage of the land, give the farmer the means for catching large quantities of the ammonia, which is floating in the air as fishes swim in the sea.

Questions.

Does the air contain anything more than oxygen and nitrogen?

Is there any ammonia in the air?

Did you ever smell any ammonia?

What becomes of any ammonia which may be in the air passing through good soils?

How can we help to pass air through the soil?

Can we make the soil work as a net?

Why do we speak of the soil acting as a net?

Can you mention one source from which the ammonia in the air often comes?

What is there to show that ammonia does escape from manure heaps?

Does a bad farmer get it back again?

[1] *The Abbotts Farm, or Practice with Science*, p. 38.

Who shares it with him?

Did the Abbotts Farm gain or lose ammonia?

What must we do to prepare our soils to work as nets catching ammonia?

To what may we compare the ammonia in the air?

Remember

There is in the air a supply of ammonia which is very valuable to our crops, and if we prepare our land properly for letting the air pass through it, we shall enrich that land by doing so. Ammonia is often lost by the bad management of farm-yard manure; and good farmers often gain some of that which their neighbours waste.

LESSON No. XXXVII.

In our last lesson we spoke of ammonia being lost from farm-yard manure—What is this farm-yard manure? It generally contains a good deal of **straw**, and this is rotted so that it may be used upon the land as manure. This straw is first used as a bedding for horses and cattle to rest upon, and thus it becomes crushed and broken up. The water then soaks into it, and after this it soon begins to rot, especially when it has become mixed with other manure. This rotting leads to many changes taking place, in the substances which are present in the manure and in the straw. When these changes *have taken* place in a proper manner, it is called

well rotted manure, and it then often looks quite black. There is a great danger of losses arising whilst these changes are taking place, but the skilful farmer tries to avoid making such losses.

You have seen boys being drilled, and according to the word of command, so they change their form and arrangement. A person who did not know how to command would soon get them into confusion, and amidst all the bustle some of the boys might go off to amuse themselves in some other way. Bad management would thus end in confusion, and in a loss from the ranks. The different bodies which are present in farm-yard manure can only be held under command by one who understands the work. If a person does not understand how to command these different bodies he soon gets them into disorder and confusion. Some go one way and some go another, and he loses first one and then another, until he has very little left to manage.

Farmers want to make the changes which are necessary in farm-yard manure in proper order and without loss, but in very many cases great losses are made. Have you ever seen small **black streams** running away from a farm-yard? There is one loss of good manure. Some of the losses we cannot see, for there are bodies which pass away into the air without our seeing them. You know how strong some smelling-bottles are, and you also know that what you feel so powerful, when you smell them, is ammonia (Lesson XIX.) Place such a bottle on a table, after taking out its stopper, and you cannot

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see anything going away from it, but you know the ammonia is passing off into the air. If any one doubts it, let him try whether it is so, or not, by smelling it. He will then be satisfied that the ammonia is passing into the air, although he cannot see it. So it is on many farms, the ammonia passes away into the air, and because the loss is not seen, it is not believed in.

Questions.

What is farm-yard manure?

Why do we want to get the straw rotted?

How is the straw used?

What happens when the straw becomes broken and wet?

Do straw and manure contain many different bodies?

Can we change the position and order of these bodies?

What results when a person does not understand how to command them?

Do we see all the losses which take place in rotting manure?

Do we see any of these losses?

Can anything pass off from the manure without being seen by us?

How can you prove that such may happen?

Is it wise to lose good manure in this way?

What should we endeavour to do?

Remember

Much of the straw of the farm is used as bedding for stock, and then it is rotted as farm-yard manure. A skilful farmer can so direct this rotting that little loss of valuable manure shall arise; but other persons are less careful, and much of the manure is therefore wasted.

LESSON No. XXXVIII.

One of the chief reasons for **farm-yard manure** being so generally useful upon the land may be traced to the fact that we are thus returning to the soil one portion of that which had been grown upon the land. In fact, we return a part of the loan made by the soil; and not only so, but we give back some of the actual materials we had borrowed. There are other cases in farm practice in which, instead of cutting the crop and having it removed from the land, we have the crop fed on the same ground from which it was produced. There is, therefore, a quick return to the soil of certain matters which had been drawn from it, and the inquiry naturally arises—do we, by feeding the crop on the land, really return to the soil all that the crop took from it?

Some persons—who are not farmers—imagine that a crop fed on the land by sheep or cattle, by some unknown process or other, really leaves the land richer and more fertile than ever. One thing is tolerably clear, namely, that when food is being

used in assisting animal growth, the food cannot in any degree build up and enlarge the body of that animal without adding to it some of its own parts; therefore, there must be a smaller quantity left for being returned to the land. The use of any body as a food causes some decrease in it, and cannot in any way increase it. Suppose, for example, that we had a crop of clover growing on a piece of land, and we divided it into two portions. On one portion the crop shall be eaten by sheep, and on the other part the crop shall be ploughed into the land. The latter must receive most fertilising matter, because the sheep would make use of a portion of the crop, and add it to their bodies.

It is desirable for you to know what it is which has been drawn from the land by the growing crop, and which is not returned to the land by the manure of the animal feeding upon the crop. Speaking somewhat generally, it may be said that it is the skeleton of the animal, which makes its growth by means of the inorganic matter which the crop took from the soil. **The bones** of the animal body are built up of substances **drawn from the soil** by plants, as much as houses may be built up of materials drawn from the builder's yard by carts and horses.

If plants could grow upon the land, and if, when they had performed their duties in life, they could return to the soil all the materials they had drawn from the ground, there would then be no exhaustion *of the soil.* The fact is, that when the plant has

made a certain growth, much of it is eaten by animals, which add some of it to their bodies, and thus the land loses materials, which are really used for making bones in the live stock which the farmer keeps upon his land.

Questions.

Why is it farm-yard manure is so useful upon the land ?

What portion of a crop is returned to the soil ?

Does this return the same bodies which had been borrowed from the soil ?

Is this better than giving the soil something which had not been borrowed ?

Does any loss arise when a crop is fed upon the land producing it ?

Does the manure return to the soil all that the crop took from the land ?

What has prevented all being returned to the soil ?

Whence do animals get the substances of which their skeletons are formed ?

Where did the plants get these same substances from ?

How are the plants useful, in helping animals to obtain necessary materials for the growth of their bones ?

What effect does this have upon the soil ?

Remember

If we only return to the soil one portion of the crop grown, we only repay a part of the loan borrowed from the soil. When a crop is eaten by cattle, or sheep, or pigs, these animals use a portion of the inorganic matter in their food, for making their bones. In this way the land is always being robbed of those materials which it contains, which are suitable for making bones.

LESSON No. XXXIX.

Of all the purchased manures which have been found most generally useful upon farms, none have been better than bones. If you remember what was explained in Lesson XXXVIII., you will soon see the cause of this being so. It was there shown that animals, in feeding upon our crops, kept back in their own bodies those materials which they needed for making bone. In this way the soil lost those bodies which are used for making bones. If we use bones as a manure, we really return to the soil those materials which the land had lost. In doing so, we repay another portion of the loan which had been borrowed from the soil. It is no wonder that bones do so much good work when used as a manure. It is just another instance of returning that which the *soil* had lost, and it was therefore likely to increase *its fertility.*

The analysis of bones shows that they contain

Organic matter,
Phosphoric Acid,
Carbonic Acid,
Lime,
Magnesia,
Soda,
Potash.

When you look over this list you only see names which are well known to you, and you know that each and all are valuable as plant-food. We need not be surprised that the land becomes poorer by their being taken away, or that the soil grows better crops when they are returned to it in the shape of manure.

There are so many purposes for which bones are used, that they would be very dear indeed if farmers did not have some other means of returning to the soil what has been taken away. In some of our rocks we find minerals which contain Phosphoric Acid and Lime, and these are known as **mineral phosphates**, and they have been used instead of bones. In many instances they have produced very good results, and have been quite as useful as bones. In other cases these mineral phosphates have not done equally good work. If you look at the list of substances which have to be returned to the soil, you will see that there are other things to be returned besides Phosphoric Acid and Lime. If we do not return to the soil all we have borrowed, there will be times when the soil will tell the farmer, "You

have only paid back a part of the materials you borrowed to make bone." We may think that as we have given back that which we think the most important, it ought to be satisfactory. We may deceive ourselves, but in the growth of our crops the truth will be made clear, whether we like it or not.

Questions.

What results have been gained by using bones as a manure?

Where did the materials come from, which are found in bones?

Why is it the bones do so much good to the soil?

Is this paying off another loan made by the soil?

Can you give the names of the substances found in bone?

Is there any one of those bodies which is not useful as plant-food?

Does their removal from the land make it poorer?

Does their return to the land make it grow better crops?

What are mineral phosphates?

What substances do they contain?

Are they always as useful as bone?

Can we pay back to the soil, by using mineral phosphates, all that the bones took away?

If we give back what we think most important, *ought* not that to satisfy the crop?

How is the truth made clear?

Remember

By the use of bones as a manure we return to the soil much of the loss which made it poor. In many cases we can use mineral phosphates instead of the bones, and at a smaller cost. Mineral phosphates are not as good as bones for all soils, because they do not return to the soil all that the bones took from the land. On some soils the whole of the loan must be repaid before any more large crops can be grown, but on other soils this is not so urgently demanded.

LESSON No. XL.

THE general object which good farmers try to secure, is the continued growth of large crops, and of good quality. The fact of a farmer doing this may generally be taken as a proof of good work, but it cannot be done, except he has that knowledge of his farm, and of the climate of the district around him, which is known as local experience. No one can farm successfully without this **local experience,** but there is no reason why a farmer should not know something more than this. In the study of the principles of agriculture, we learn **why** it is some practices give better results than others. Whether a farmer succeeds in his business or not, depends upon his skill as a man of business, helping him to overcome the difficulties which oppose him. If he

has had experience as a practical farmer, it will still be an advantage to him if he also knows why his practice has been successful, and why in some cases it has failed. However good a man of business he may be, he will have many advantages if he should also have a thoroughly intelligent mind to help him in his work.

Every one who studies the principles of agriculture should know that such knowledge is useful in preparing any one for learning the business of farming with accuracy, and with an intelligent mind. But the principles of agriculture do not teach the business of farming, which must be learnt, and can only be learnt, by taking part in the work of the farm. The farmer who knows how and when work should be done on his farm, would look upon it with greater interest if he also knew why it should be done in that particular manner. If he had to farm another kind of soil and in another district, he would also be better able to learn the changes of management which were necessary.

So also, if a boy is going to learn farming, he will have many advantages if he enters upon the work with his eyes open, and with his mind prepared for thinking about his duties in an intelligent manner. **The danger** which has to be avoided is the foolish notion that the actual work of the farm is so very simple that no one need learn how to do it. Every farmer should know how the work of the farm should *be done,* and he will then be able to judge fairly of *those who* are doing it.

The more you know of the principles of agriculture the more you will be interested in farm work. Farming will never be to you a dull routine of labour, for it gives more room for thought, and fuller opportunities for the exercise of an intelligent mind, than any other profession or occupation which engages the attention of educated minds.

Questions.

What are the objects good farmers seek to gain?

What do you understand by a farmer's local experience?

How does this guide a farmer?

Is there any advantages to be gained by a farmer being also a generally intelligent man?

Does a knowledge of the principles of agriculture help a good farmer?

If you learn much of the principles of agriculture, can you be a good farmer if you have not also learnt the business?

How must this be learnt?

What is the advantage of learning the principles of agriculture?

Is there a danger to be avoided?

What is that danger?

Is it really desirable to learn how the work of the farm should be done?

Does a knowledge of the principles of agriculture make farming more interesting, and more profitable?

Remember

A knowledge of the principles of agriculture, assists persons to enter upon the business of farming with intelligent minds. It should not be looked upon as in any way decreasing the necessity for the business of farming being properly learnt. It makes farm practice an occupation in which the most educated minds may find delight, and, when associated with a good practical knowledge of the business of farming, it will contribute greatly to its successful conduct.

THE END.

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